"Sparking Teens' Interest in Emergency Response Technology through Teen Science Cafés"

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Abstract
Natural disasters are increasing at a rapid rate, with the Centre for Research on the Epidemiology of Disasters reporting that climate-related disasters occurred more than twice as frequently, on average, from 2000 to 2015 in comparison to the 1980s. Disaster education, on the other hand, is sparse and unsystematic. The goal of our work was to develop brief and impactful educational interventions, accessible to teens throughout the country, and that focused on using technology to confront natural disasters. We did this through the Teen Science Café Network, a group that sponsors out-of-school events led by youth, featuring hands-on activities and community STEM practitioners who described their work and career pathways. The program was implemented in 19 sites nationwide, with 502 youth. Themes of these cafés included flooding, hurricanes, and wildfires. A project-designed survey established much-needed baseline data, showing that youth have limited knowledge about how technology can mitigate disasters (an average score of 4.2 correct answers on a 10-item multiple-choice test). We discuss the interest-shaping and life-saving potential of community STEM interventions that address how rapidly emerging technologies are used to prevent and respond to natural disasters.

Keywords/phrases
Emergency Response Technology
Teen science cafés
Natural disasters
Informal STEM education

Goal

In the face of continuing and escalating natural disasters (see, especially, Centre for Research on the Epidemiology of Disasters, 2015, p. 7), including the wildfires that are destroying sections of California, as well as the many hurricanes that are devastating coastal areas, we are confronting this challenge: How do we make teens aware of the myriad applications of STEM—especially technology—to predict, monitor, and mitigate these damaging events? This topic may be of great personal interest to teens, many of whom live in areas impacted by disasters. In addition, it is vital that teens learn about and consider professional and volunteer roles they might play in the future to address these disasters locally and globally.

The Platform: Teen Science Cafés

Teen science cafés (https://teensciencecafe.org/about/) are an ideal way for teens to learn about the role of technology in preventing or mitigating natural disasters. Unlike school-based programs, cafés are run by teens themselves, and are a free and fun way for them to explore big advances in science and technology that are affecting their lives. As of 2019, there were 130 café programs nationwide, with each site deciding upon its own venue (typically through 4-H programs, science centers, libraries, or universities) and its own agenda and schedule (see https://teensciencecafe.org/cafes/). A given site hosts 5–7 cafés per year, and teens play a major leadership role in arranging for and implementing the cafés. They engage in lively conversations with scientists/technologists of all kinds who have various amounts of training, from two-year degrees through PhDs. Participants also are immersed in hands-on activities that relate to the café's topic and/or the work done by the speaker. Our research shows that teens enjoy the blend of the social and the intellectual, and come to better understand the nature of STEM and the interesting lives that scientists lead. They become comfortable talking about science with others, gain appreciation of the relevance of STEM in their lives, and begin to consider different viewpoints. Some discover the possibility of a life in STEM for themselves that had never occurred to them before (Author, 2012; Sickler, 2018).

Background

We chose the topic of Emergency Response Technology (ERT) as a thematic focus for a series of 19 cafés held nationwide. There were several reasons for this thematic choice. First, we wanted participants to learn about the blossoming of STEM careers in emergency response and management, and how these careers are enabled by rapidly emerging technologies. The technologies used in the field of emergency management include drones, GIS, and thermal imaging to respond to hurricanes and fires and to aid in search and rescue missions (FLIR, 2019; Klein, 2019; Libby, 2018; Restas, 2015). They also involve the use of social media, apps, and other cell phone features to help people communicate vital information as they prepare for disasters and find shelter and aid after disaster strikes (Disaster Information Management Research Center, 2019; Palen & Hughes, 2017; Teen Science Café Network, 2019b). 5G cellular technology seems poised to transform emergency response communications in the near future (Reichert, 2019). Other notable technologies include deploying underwater gliders to track the path and strength of hurricanes, the use of sensors to track water level rise during floods, or the use of artificial reality sand-tables to simulate the behavior of fire and wind in a given terrain (Shepherd, 2019; Sallah, 2019; USGS, 2019). These new technologies help people prepare for natural disasters and find support after they occur.

These technological innovations demand new skills and considerable expertise from first responders and other STEM practitioners involved in emergency response. Yet efforts to teach youth—the next generation of emergency responders—about these important technologies and careers are limited. The Next Generation Science Standards (NGSS) includes K–12 guidelines for activities and learning goals on Natural Hazards (topic ESS3), but little on the uses of technology in addressing these natural hazards (NGSS, 2013). There are free, focused curriculum resources on the topic available for educators through organizations like FEMA, though these often address the urgent and immediate actions individuals can take to protect themselves during disasters (Ready.gov, 2019). The most concerted efforts to teach youth about emergency response occur outside of the classroom, typically through programs such as FEMA's Teen CERT or MyPI, often offered through 4-H clubs, Boy Scouts, Girl Scouts, or similar youth enrichment organizations (FEMA, 2010; Johnson et al., 2014; MyPI, 2019). The technology focus of these programs tends to be limited to practical skills; for example, MyPI has a "technology track comprised of awareness programs focusing on HAM Radio, NOAA Weather Radio, Smoke Alarm Maintenance, and Smart Phone App and Social Media in Emergency Preparedness" (MyPI, 2019). A notable exception with a more in-depth technology focus is the K–12 Disaster Engineering curriculum resources on the eGFI website, which includes activities such as "Building for Hurricanes" (American Society for Engineering Education, 2019).

Another major reason for implementing these ERT thematic cafés is that disaster response demands civic engagement by all of us. Everyday citizens who volunteer during disasters, even if simply to keep their own families safe, have a considerable advantage if they are familiar with life-saving technologies. Consider the example of residents of a small town in Minnesota coming together to find a lost 6-year old (Klein, 2019). Hundreds of volunteers combed through swampy woods and cornfields on a cold night to rescue the boy and his dog. A volunteer drone operator, with a thermal camera attached to his drone, ultimately was able to locate the pair by searching for temperature differentials between the cold ground and the much warmer boy and dog. The operator then focused the drone's lights on the scene so that volunteers nearby could quickly locate the child, who was cold, but unharmed. This kind of crisis regularly occurs at much larger scales, when people suddenly are forced to leave their homes due to a natural disaster and need to be evacuated, found, or rescued. Technology, combined with the expertise of professionals and volunteers, saves lives.

Theoretical Foundation

For the work reported on below, we use Renniger and Hidi's (2019) theory of interest development as a framework. These researchers contend that interest can be stimulated "at any age and in any context" (p. 282) and that situations that stimulate interest involve the presence of challenge and opportunity, as well as considerable collaborative support from peers and/or adults. Likewise, Gutwill and Allen's research (2012) demonstrates that a collaborative environment that fosters "active prolonged engagement" is important in cultivating teens' interest.

Interest development unfolds in several stages (Hidi & Renniger, 2006), the first of which is "triggered situational interest." In this stage, youth discover a particular content area and experience a positive psychological state that is characterized by questioning and curiosity. While the exact "triggers" of interest vary from one teen to the next, we have found that many teens are interested in natural disasters that affect their own communities, and that they are especially interested in discovering more about their own utility and relevance in disaster situations. Their attention may be captured by the urge to understand what is happening and to be helpful in responding to the situation. In some situations, interest is triggered by what they see happening to friends or family members in the context of threatening or impending disasters. These events may promote an information search in attempt to make sense of the situation and figure out what can be done about it.

Teen science cafés may offer a “just in time” opportunity for teens to become interested in the intersection of technology and natural disasters, as well as the careers and volunteer roles associated with this field. They can provide youth with an accessible introduction to emergency response technology, often though the lens of a topic directly relevant to their area of the country, led by a local STEM practitioner who will spark their interest to learn more about the field and perhaps pursue it professionally.

Implementation of the ERT Cafés: A Vignette

To provide the reader with a sense of how a café unfolds, we outline the story of a café in Oxford Hills, Maine, where a 4-H organization and school district worked together with an aviation specialist from the University of Maine, Augusta. The 4-H educator and school personnel worked with a group of teen leaders who were especially interested in the café’s topic, and who marketed and hosted the event. In the Oxford Hill café, the topic was “Drone Technology in Hurricane Emergency Response,” and the presenter was Colonel Dan Leclair.

This café took place on a cold winter day, right after school, and was held in a large area suitable for drone flight. Teen leaders greeted and signed-in the 20 or so teens who attended (along with a handful of adults), helped the presenter set up his equipment, and served refreshments. After the participants (some from the high school, some who were home schooled) had mingled and had refreshments, Colonel Leclair started the café by briefly introducing his work, and showed many photos as he talked. He began like this:

“‘If you’re a pilot, you’re often called to help in emergencies. As a member of the Civil Air Patrol I directed an important mission to assess the damage after Hurricane Sandy in 2012. We had 400 pilots and 80 aircraft flying in a complex pattern over the damaged area, and we took hundreds of thousands of photos. Then, we stitched these photos together digitally, using data from the meta files of the photos that were taken. Today, we do this kind of work with drones that have cameras attached to them. Drones can go where people can’t, which makes them especially useful during emergencies like floods, hurricanes, and fires. To do this kind of work with drones, you need to have a commercial FAA drone pilot license. It’s an important credential to have, and I’m working with young people through the Civil Air Patrol youth program as well as my students at the University to get more people into this field.’ Leclair went on to explain that one needs only 30 credit hours at a college—including classes in photography, math, technology, and aviation—to become a certified drone pilot” (Author, 2018).

Once they heard about drones and their uses in response to natural disasters, the group got a chance to examine prototypes that Leclair had brought, build a drone from an inexpensive kit, and learn to fly small quadcopter drones. The group practiced using the throttle, yawing, launching, navigating through people’s arms, and landing on someone’s hand, which was the most difficult task of all. Some teens discovered that it is not very hard to build a drone from scratch, if you have the right kit and are comfortable with assembling mechanical objects by assembling their component parts. The finale of the café involved instructing a drone to take a selfie of the assembled group of approximately 20 teens and assorted teachers, parents, and adult leaders.

As this vignette shows, the major elements of a 90-minute café are simple: A presenter who is passionate about their work and is able to share it in a succinct and compelling manner with teens; a core group of teens who take leadership responsibility for the event; a cool and engaging ERT-related hands-on activity; and an adult leader or two (in this case the 4-H leader and the school's Director of Experiential Learning) to orchestrate. While each café is different, and much depends upon the topic, the presenter, the hands-on activity, and the structure is straightforward and generalizes to many types of settings.

Implementation of the ERT Cafés: The Data

Between January 2018 and April 2019, a total of 19 cafés on ERT topics were held at 18 sites around the country. A range of topics was covered, including emergency medicine, the use of drones in responding to hurricanes, and using GIS to map fire evacuation routes. In total, 502 teens participated in ERT cafés, with an average of 26 participants per café. Table 1 lists all of the 19 ERT cafés, organized by the general topic. In cases where a "Cool Café" blog post was written about the café, a link to that post is included in the final column. The reader is encouraged to visit those links to learn more about what happened at a specific café, including who the presenters were and what their backgrounds are in ERT.

Table 1:
List of the 19 Teen science cafés on Emergency Response Technology in Natural Disasters

Café no.	Date	Topic	No. of participants	Place	Place type	Institutional affiliation(s)	Link to blog post on café
1	Nov. 2018	**Avalanches**	30	Boulder, CO	Urban	University of Colorado Boulder Science Discovery program	http://bit.ly/2KfKi1C
2	Jan. 2018	**Blizzards**	1	Buffalo, NY	Urban	Penn Dixie Fossil Park and Nature Preserve	N/A
3	Mar. 2019	**Building for natural disasters**	25	Wilmington, DE	Urban	Delaware Museum of Natural History	http://bit.ly/33IrbVB
4	Apr. 2019	**Earthquakes**	8	Sammamish, WA	Urban	Sammamish YMCA	http://bit.ly/2CAQop9
5	Oct. 2018	**Emergency medicine**	34	Albuquerque, NM	Urban	N/A	N/A
6	Oct. 2018	**Emergency medicine**	29	Rio Rancho, NM	Urban	Explora science center	http://bit.ly/2QcVYpU
7	Oct. 2018	**Flooding**	68	St. Louis, MO	Urban	N/A	N/A

8	Oct. 2018	**General emergency response**	44	Española, NM	Rural	N/A	N/A
9	May 2018	**General emergency response**	53	Los Alamos, NM	Rural	N/A	N/A
10	Jan. 2018	**Hurricanes**	15	Corpus Christi, TX	Urban	Texas State Aquarium	http://bit.ly/33GTeVC
11	Mar. 2018	**Hurricanes**	19	Machias, ME	Rural	University of Maine, Machias; 4-H	N/A
12	Mar. 2018	**Hurricanes**	26	Oxford Hills, ME	Rural	N/A	http://bit.ly/33Getql
13	Feb. 2019	**Hurricanes**	24	New Brunswick, NJ	Urban	Rutgers University; 4-H	N/A
14	Apr. 2018	**Search and Rescue**	15	Machias, ME	Rural	University of Maine, Machias; 4-H	http://bit.ly/2paM4d5
15	Mar. 2019	**Tornadoes**	35	DeKalb, IL	Smaller city	Northern Illinois University; Illinois Math and Science Academy	N/A
16	Oct. 2018	**Wildfires**	35	Santa Fe, NM	Urban	Santa Fe Indian School	http://bit.ly/34RJw2O
17	Jan. 2019	**Wildfires**	27	Farmington, NM	Smaller city	N/A	N/A
18	Jan. 2019	**Wildfires**	8	Las Cruces, NM	Urban	Las Cruces Museum of Nature and Science	N/A
19	Apr. 2019	**Wildfires**	6	San Diego, CA	Urban	N/A	http://bit.ly/2KbYmZV

A number of trends can be seen in this table. First, a majority of cafés (13 of the 19) focused on ERT-related topics relevant to the regions where the cafés were held, including cafés on hurricanes that were held in coastal areas and cafés on wildfires held in the Southwest. Note that the café on blizzards (no. 2) ended up occurring during a blizzard, so only one student showed up—but in true upstate New York fashion, they soldiered on! The remaining cafés focused on general technologies applicable to responding to a more general range of emergencies.

The majority of cafés (12 of them) were held in urban areas, five in rural areas, and two in smaller cities. Many of the cafés, particularly the ones held in urban areas, attracted youth from surrounding communities. Five of the cafés were affiliated with or hosted by science centers, six with universities, colleges, or high schools, three with 4-H programs, and one with a YMCA.

Presenters at the ERT cafés included: a firefighter specializing is the interface between wild and urban lands, a university GIS professor, an architecture student, and a game warden, among others. For more details on specific presenters and cafés, consult the blog posts listed in the table above.

Baseline Survey: Method and Results

A research goal of our work was to collect baseline information on teens' level of knowledge about the role of technology in responding to natural disasters. To our knowledge, the field has not developed measures of knowledge of this increasingly important domain. We developed a quick and easy-to-administer multiple-choice measure, which we presented as a "trivia game" to be done sometime during the 90 minute café. Note that we did not track pre- to post-café changes in knowledge, because the cafés emphasized very different pieces of technology as well as different types of natural disasters. Rather, we wished to establish a starting point, so that other researchers who are engaged in ERT efforts with teens have both an instrument and baseline data to use in their work.

With a convenience sample of 170 teens (of the 502 who participated in ERT cafés), we gathered more detailed demographic information from participants (gender and age) along with their responses to the questionnaire. In this sample, 52.4% of participants were girls, 43.5% were boys, and 4.1% specified other genders or did not specify gender. The majority of participants in the sample (87.1%) were in our target age range of 13 to 18 (the remaining participants were younger or did not specify age). Of the participants in our target age range, the average age was 15.0.

The questionnaire had ten items about the use of technology in response to a variety of disasters. Seven of the questions had three possible answers to choose from; the remaining three questions each had four possible answers. The responses show that youth attending the cafés had a low level of knowledge about ERT. The average correct response rate was 42.18%, with between 8.24% and 71.76% of participants answering any individual question correctly. The rate of correct responses was only slightly higher than chance: on average, there was a 30.83% chance of correctly guessing the answer to a question.

Figure 1 lists the ten questions, their answers, the percentage of participants who answered each question correctly, and the chance of correctly guessing each answer. An asterisk in front of an incorrect answer indicates it was selected more often than the correct answer. Five questions had incorrect answers that were selected most often. Note that in items 9 and 10, all of the incorrect answers were selected more frequently than the correct answers, suggesting that teens' knowledge of these particular two topics (avalanches and coronal mass ejections) is especially limited.

Figure 1:
Enumeration of the individual items on the baseline questionnaire. The full questionnaire can be found at http://bit.ly/3359aj9.

Item 1: What should you do if floodwaters are approaching your home?
Correct answer: Use a smart phone app to locate the nearest shelter and go to it.
Incorrect answers: *Call 911 to find out how bad the flooding will be; Go to the attic to wait it out.
31.76% of participants answered correctly (33.33% chance of guessing correctly)

Item 2: What should you do if you live on the coast and an earthquake strikes offshore?
Correct answer: Get to high ground as fast as possible
Incorrect answers: Consult the tsunami alert app on your smart phone; Go to the attic to wait it out.
61.76% of participants answered correctly (33.33% chance of guessing correctly)

Item 3: What is the best technology for predicting the path and strength of a hurricane?
Correct answer: Satellite sensors
Incorrect answers: Radio reports from ships at sea; A large number of reports from local TV and radio stations.
71.76% of participants answered correctly (33.33% chance of guessing correctly)

Item 4: What is the best technology for predicting the path and strength of a tornado?
Correct answer: Doppler radar
Incorrect answers: Satellite sensors; A large number of reports from local TV and radio stations; Clicking your ruby slippers three times and saying "there's no place like home."
50% of participants answered correctly (25% chance of guessing correctly)

Item 5: What is the most important thing to measure to predict the destructive potential of a hurricane?
Correct answer: Barometric pressure
Incorrect answers: *The speed of the hurricane's advance; The temperature of the air around the hurricane; The hurricane's name in alphabetical order for the season.
40.59% of participants answered correctly (25% chance of guessing correctly)

Item 6: What should you consult if you're considering buying a house in an area prone to flooding?
Correct answer: GIS-based maps of recent flooding events
Incorrect answers: Army Corps of Engineers maps of the 100-year flood plain; Multiple real estate agents.
54.12% of participants answered correctly (33.33% chance of guessing correctly)

Item 7: What is the best way to detect spot wildfires?
Correct answer: Deploy a drone
Incorrect answers: Deploy your team on roads leading to the main fire to conduct a search; Consult Landsat satellite imagery.
46.47% of participants answered correctly (33.33% chance of guessing correctly)

Item 8: Following a major earthquake, the highest priority of an emergency manager is to…
Correct answer: Get the electrical system back up
Incorrect answers: Get the roads and bridges repaired; *Get seismometers deployed to monitor aftershocks.
34.71% of participants answered correctly (33.33% chance of guessing correctly)

Item 9: The best way to search for buried people following an avalanche is to…

Correct answer: Conduct a transceiver survey

Incorrect answers: *Bring in the specially equipped excavator-tractors; *Conduct a survey with special snow probes; *Use a well-trained St. Bernard dog with a GPS sensor attached to its collar.

8.24% of participants answered correctly (25% chance of guessing correctly)

Item 10: There is a giant coronal mass ejection from the sun heading straight for Earth. As an emergency manager, you are most concerned with…

Correct answer: De-coupling the national power grid

Incorrect answers: *Monitoring resulting lighting strikes that may cause fires; *Deploying the national network of Geiger counters.

22.35% of participants answered correctly (33.33% probability of guessing correctly)

Responses did not vary substantially across age or gender. For instance, the average correct response percentage for girls (n = 89) was 40.1%, while for boys (n = 74) it was 44.9%. For the 148 participants in our target age range (13–18) who completed surveys, the correlation coefficient for age versus total number of correct responses was -0.0163. This suggests that there are no particular age groups where youth have greater knowledge of ERT.

Discussion

Over the course of less than two years, members of the Teen Science Café Network (TSCN) enthusiastically implemented 19 cafés on a wide range of natural disaster topics. What was common to their cafés was the emphasis on the uses of new technology in disaster work, as well as the highlighting of cutting-edge professional work done by the café presenters. The "Cool Café" blog posts cited in Table 1 indicate that youth were eager to participate in these cafés, in part because of the immediate relevance of the topics in areas of the country experiencing hurricanes, flooding, or wildfires. According to one leader from New Mexico, who implemented a café on wildfires: "Having these cafés that focus in on natural disasters, I think it's just so relevant for the kids living in those communities. They can totally relate to it. They can see the jobs that are available in these fields and that it's attainable for them."

Three things are clear from our work: 1) Youth need and want to know about the vital roles they can play by learning to use technology in the face of natural disasters; 2) Teens currently know little about the uses of technology in mitigating or responding to disasters; and 3) Teen science cafés provide a timely and relatively simple way of sparking interest in this topic. The project showed that it is possible to empower youth to become involved, shape their futures, and care for their communities in the face of disasters.

We plan to expand the theme of Emergency Response Technology within the Teen Science Café Network. Anyone with an interest in starting their own teen science café program that includes an element on natural disasters and technology can start by sending a note to the "contact us" link on the TSCN website. The resources developed by the project are available to any educator (see: https://teensciencecafe.org/resources/). Reaching teens with proactive messages about their own agency in natural disasters is imperative and attainable through teen science cafés.

Conclusion

There is a vital need for teens to understand more about ERT. Their level of knowledge on this topic is quite low currently. Teen science cafés on ERT that spark their knowledge and interest and get them involved is a good first step. There is a place for everyone in emergency response, but we need to make the wide range of skills and careers more visible.

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